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THE RELATION OF FLOOD TIMING AND DURATION TO VARIATION IN SELECTED BOTTOMLAND HARDWOOD COMMUNITIES OF SOUTHERN ARKANSAS

by

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This research examined the significance of flood timing and duration to community structure in bottomland hardwood forests of the Ouachita River Basin of Arkansas that are typically flooded for less than a total of 30 days during the growing season. Results of the study provide evidence that the structural development of floodplain forest communities is influenced by the timing and duration of floods that occur during the growing season. Significant correlations were found between the development of juvenile forms

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20. ABSTRACT (Continued).

(seedlings and saplings) of *Carpinus caroliniana* Walt. (ironwood), *Quercus falcata* Michx. var. *pagodaefolia* Ell. (cherrybark oak), *Quercus nigra* L. (water oak), *Liquidambar styraciflua* L. (sweet gum), and *Nyssa sylvatica* Marsh. (blackgum) and varied flood timing and duration patterns occurring between 1962 and 1974.

Preface

This paper is a slightly updated version of a technical presentation made at the 11-13 December 1978 National Symposium on Strategies for Protection and Management of Flood Plain Wetlands and other Riparian Ecosystems, Callaway Gardens, Georgia. It presents scientific information significant to the understanding of the relationship of bottomland hardwood community structure with the timing and duration of floods.

Initial data collection began in 1974 as part of the author's graduate research (NSF Grant No. BMS 75-19617) at the University of Arkansas, Fayetteville. This research was further pursued and completed as part of the wetlands criteria research efforts being conducted under the Dredging Operations Technical Support Program (DOTS), Environmental Laboratory (EL), U. S. Army Engineer Waterways Experiment Station (WES). The overall objective of the wetlands criteria research effort is to provide field personnel with technical criteria and methods that can assist them in the onsite delineation of boundaries between wetland and nonwetland habitats as required by Section 404 of the Clean Water Act.

Technical reviewers included Dr. J. W. Wooten, Professor of Biology, University of Southern Mississippi, Hattiesburg; Mr. T. R. Patin, Civil Engineer, DOTS; Mr. C. K. Klimas, EL; Dr. A. E. Radford, Professor of Botany, University of North Carolina, Chapel Hill; Dr. R. T. Saucier, Special Assistant, EL; Dr. G. E. Tucker, Professor of Botany, Arkansas Tech University, Russellville; and Dr. J. S. Wilson, Professor of Botany, Emporia State University, Kansas.

The author served as principal investigator on the study and prepared this paper under the general supervision of Mr. C. C. Calhoun, Program Manager, DOTS; and Drs. H. K. Smith, Ecologist, Wetland and Terrestrial Habitat Group, Environmental Resources Division (ERD), EL; C. J. Kirby, Chief, ERD, EL; and John Harrison, Chief, EL.

Commanders and Directors of WES during the presentation and preparation of this paper were COL John L. Cannon, CE, and COL Nelson P. Conover, CE. Technical Director of WES was Mr. F. R. Brown.

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THE RELATION OF FLOOD TIMING AND DURATION TO VARIATION IN SELECTED BOTTOMLAND HARDWOOD COMMUNITIES OF SOUTHERN ARKANSAS

Introduction

1. Soils within active floodplains differ from surrounding soils due primarily to inundation which results in anaerobic conditions throughout the soil column except for a thin aerobic layer at the soil-water interface (Ponnamperuma 1972). Anaerobic conditions are one of the most important factors in the evolution of bottomland hardwood forest species because these species must conduct various life processes under such conditions. Tolerance to anaerobic conditions by bottomland hardwood taxa is quite varied (Whitlow and Harris 1979). Most researchers believe that anaerobic tolerance by plants is a result of specialized biochemical processes and/or physical adaptations (Kramer 1969; Crawford 1969). In addition, it has been shown that anaerobic conditions act as a selecting agent primarily during the growing season and have little or no effect on dormant populations (Sigafoos 1964; Burgess, Johnson, and Keammerer 1973).

2. In contrast to individual or species tolerances, little is known as to how plant community structure is influenced by flooding events. It appears that bottomland community structure is determined or maintained by the duration and timing of flooding during the growing season. This research examines the significance of flood timing and duration to community structure in bottomland hardwood forests that are typically flooded for less than a total of 30 days during the growing season.* The area of study lies within the Ouachita River Basin of Arkansas.

General Features of the Study Area

3. The study area is located in southern Arkansas within the

* Growing season--25 March to 10 November.

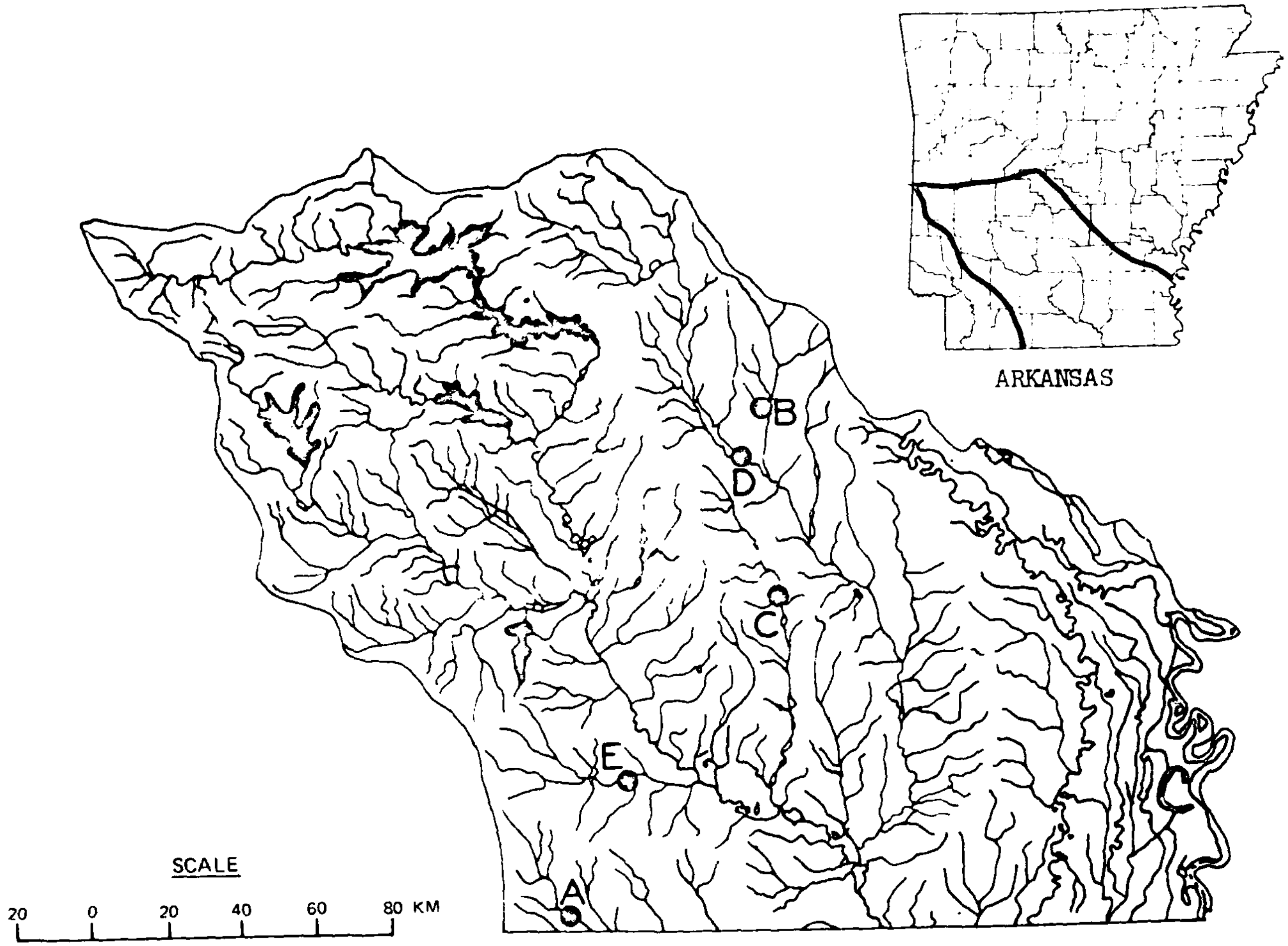


Figure 1. Arkansas portion of the Ouachita River Basin drainage pattern and location of the five study areas (A = Cornie Bayou; B = Hurricane Creek; C = Moro Creek; D = Saline River; and E = Smackover Creek)

Ouachita River Drainage Basin (Figure 1), a subbasin of the Lower Mississippi River. Soils are composed largely of marine and fluvial deposits of sand, silts, and clays; those on the study sites consist primarily of fine-grained sediments. The climate is fairly typical for southern Arkansas with long, hot summers and cool and short winters. Average summer temperature is 26.6°C; the average daily maximum is 32.7°C. Average winter temperature is 6.6°C; the average minimum temperature is 0°C. The average dates for the first and last killing frosts are 10 November and 25 March, respectively. Fifty four percent (about 0.7 m) of the total annual precipitation usually falls from April through September; snow is rare and seldom exceeds 5 cm. The average relative humidity is about 60 percent; the average sunshine is 52 percent in the winter and 72 percent in the summer (U. S. Department of Commerce 1962-1974). Flooding within the study area typically occurs during the late winter and spring months (February-June).

Methods

Site selection

4. The study sites were selected to meet the following criteria (1) stream gauge data indicated that the site was subject tot periodic flooding conditions for less than a total of 30 days during the growing season; (2) the site covered a minimum area of 2 ha; (3) the site was protected by a buffer strip of forest vegetation at least 30 m in width; (4) the site was located within 200 m of a United States Geological Survey (USGS) continuous recording streamflow station; (5) the site, as far as could be determined, had not been excessively disturbed by grazing, logging activities, fire, or excessive diltation; (6) the stage-discharge relationship of the watercourse at the site was defined by the USGS, and no great amount of streamflow could bypass the streamflow station; and (7) the surface of the site was essentially flat. Five sites within the river basin were selected for study (Figure 1).

Vegetation sampling

5. During the spring, summer, and autumn of 1975, quantitative phytosociological data on the vegetation of each site were collected.

These were obtained by sampling a minimum of ten 0.04-ha rectangular plots located at random within each of the selected study sites (Penfound and Rice 1957; Kershaw 1973). This areal method of sampling was selected because it is a simple and accurate way to sample small plots of known size and to extrapolate estimates of density and basal area for the entire site (James and Shugart 1970).

6. Specifically, within each study plot, all trees and shrubs $\geq$2.5 cm in diameter breast high (dbh) and $\geq$1.3 m tall were sampled, and data recorded in size classes of (1) $\geq$2.5 cm to <15.0 cm, (2) $\geq$15.0 cm to <38.0 cm, and (3) $\geq$38.0 cm. The density, basal area, and percent frequency of each species were calculated. The densities and percent frequencies of saplings and shrubs <2.5 cm dbh and $\geq$1.3 m tall were also determined. Percent cover estimations of vegetation <1.3 m tall were made within each 0.04-ha rectangular plot using a scale for guide estimation similar to that described by Phillips (1959).

Collection of streamflow data

7. Streamflow was recorded by a USGS continuous recording station located within 200 m of each site. The average period of record for each streamflow station was 13 years. The occurrence of flooding for the period of record was determined through the use of USGS daily discharge records and rating curves.

Data analyses

8. Both streamflow and vegetation data were analyzed using the IBM-370 Model 155 digital computer and the Statistical Analysis System correlation program for the SAS package (Service 1972).

9. Basal area of the size class $\geq$2.5 cm to <15.0 cm dbh was used as a response variable to represent each dominant woody species selected for analysis. Selection of this size class was done to provide a representation of the woody vegetation at each study site that had germinated and developed mainly during the past 13 years of streamflow record.

10. Concomitant variables selected represented various aspects of flood timing and duration found within the study area. The rationale for the flood timing and duration variable design and selection was that seedling mortality of the dominant floodplain tree species encountered

in this study begins to occur during floods equal to or greater than 5 days (Hosner 1960). The assumption was made, therefore, that the selected flood timing and duration variables are describing environmental circumstances that affect the fecundity of these species since those species with better juvenile survival rates during a specific type of flood have a greater chance for success and this should be related to the response variable, basal area, for each species studied. Using the USGS daily discharge records and rating curves, letter designations were assigned to certain frequencies of flooding events and the time of their occurrences during the growing season (Table 1).

Results

Variation in time and duration of flooding

11. The five study sites were found to have noticeable differences in the timing and duration of floods, particularly during the growing season (*Figure 2*). Floods usually occurred during the early and midspring portions of the growing season with one- to three-year period between seasonal occurrence of events and a duration for each event ranging from 1 to 19 days. As previously noted, Table 1 lists the categories assigned to these flooding events according to their frequency and time of occurrences during the growing season.

Vegetation structure

12. As would be expected, the vegetation of the five sites examined was not uniform. The composition of the dominant (highest basal area) overstory vegetation was found to be dissimilar (Tables 2-6), whereas that of the subcanopy (<2.5 cm dbh) was not in that it was typically dominated by *Carpinus caroliniana* Walt. (ironwood). The shrub and herb layer vegetation, which was also quite variable, was found to occur primarily in dense patches beneath open areas in an otherwise dense, leafy overstory (Table 7).

Habitat-species relationships

13. Correlation analysis showed that the plant communities in the sites studied responded differently to the various flood timing and

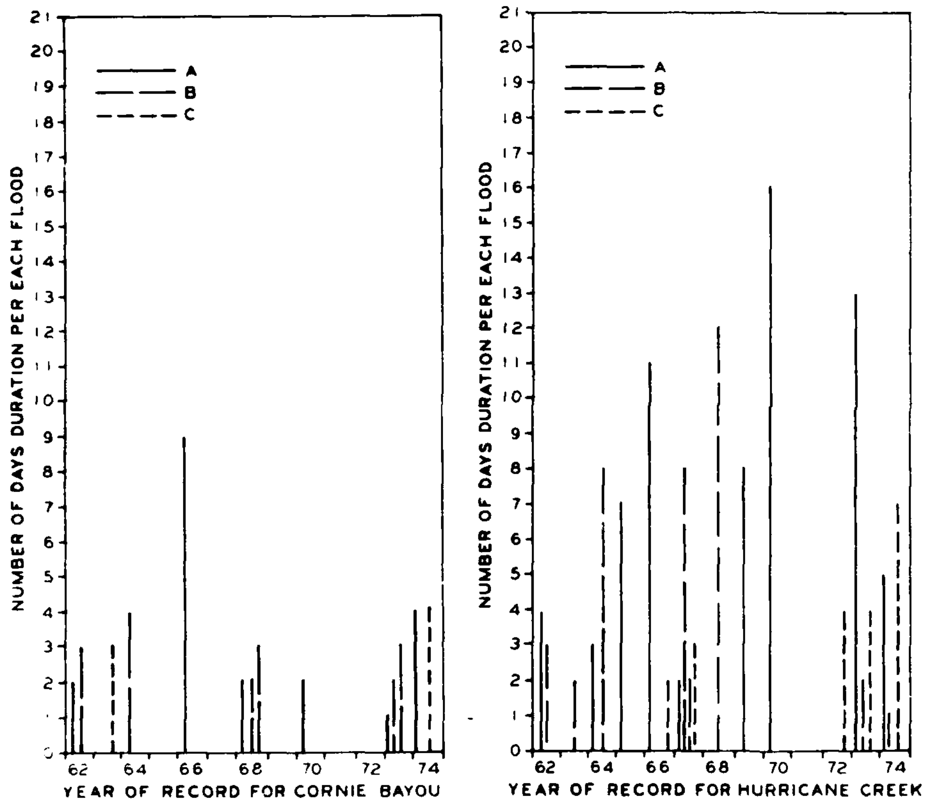
Table 1

Categories for the Timing and Frequencies of Flooding During the Growing Season* and Their Letter Designations

Letter Designation	Recurring** Flooding Events with a Duration Equal to or Greater than Five Days
A	Occurring during the early spring portion of the growing season (late March to mid-April)
B	First occurrence(s) during the early spring portion of the growing season (late March to mid-April) followed by occurrence(s) during the spring portion of the growing season (mid-April to mid-May)
C	Two or more floods occurring at variable times during the growing season
D	Occurring after mid-May

* Growing season--25 March to 10 November.

** Typical flooding event with a one- to three-year frequency over a 13-year period.



Time of flood occurrence:

A - early spring portion of the growing season (late March to mid-April)

B - midspring portion of the growing season (mid-April to mid-May)

C - late spring and summer portions of growing season

Figure 2. Flood patterns within the floodplain habitats studied (1962-74) (Continued)

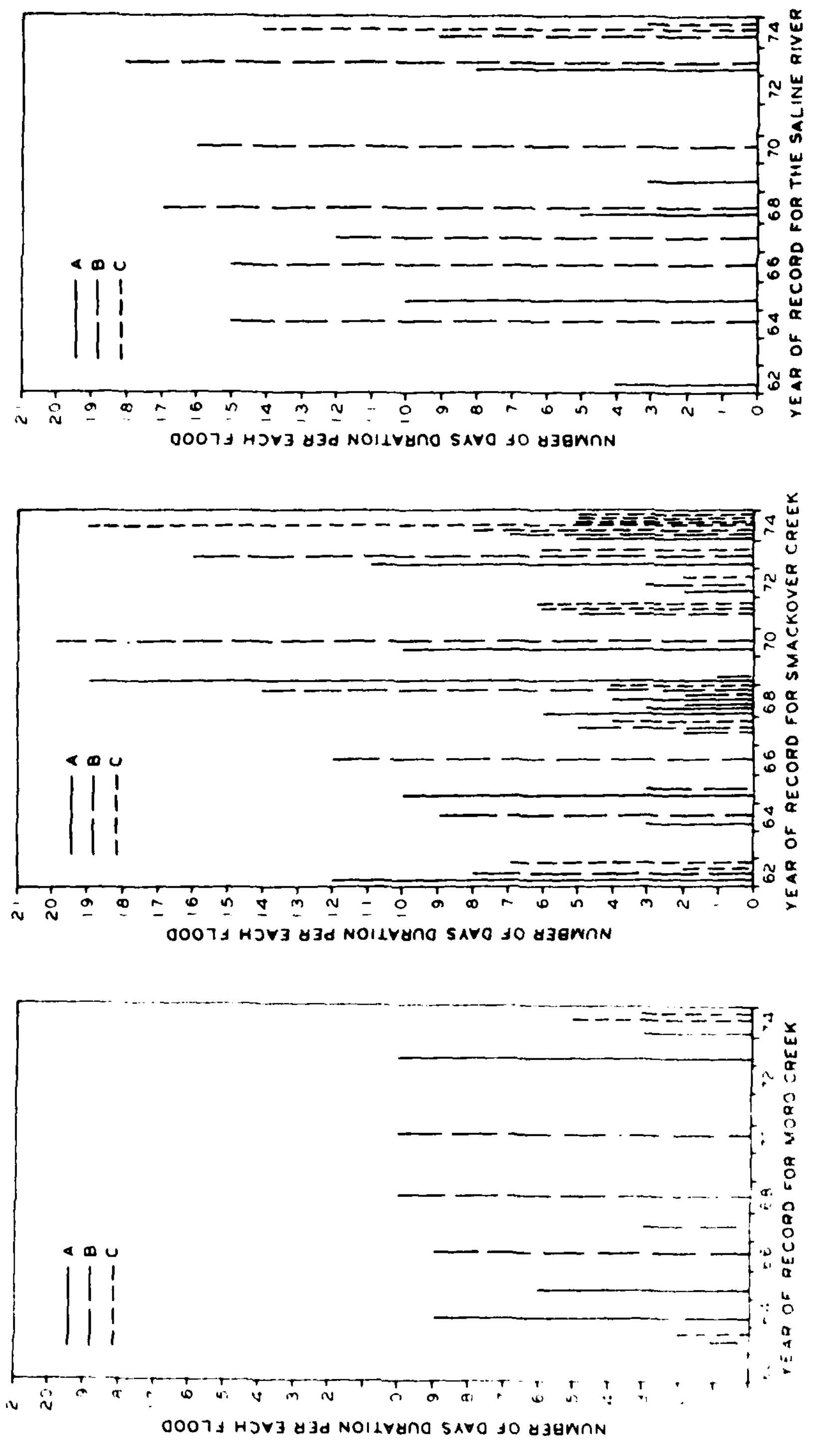


Figure 2. (Concluded)

Table 2

Composition of the Woody Flora of the Cornie Bayou Study Area*

	Saplings dbh <2.5 cm		Trees dbh ≥2.5 cm to <15 cm			Trees dbh ≥15 cm to <38 cm			Trees dbh ≥38 cm			Total For All Size Classes	
Species**	F	D	F	D	BA, m^2	F	D	BA, m^2	F	D	BA, m^2	D	BA, m^2
Quercus falcata Michx. var. *pagodaefolia* Ell.	10	1	10	2	0.37	6	8	9.66	30	3	8.64	14	18.67
Quercus nigra L.	10	2	20	4	0.74	50	8	7.80	20	2	7.43	16	15.97
Carya ovata (Mill.) K. Koch	50	8	10	1	0.28	0	0	0	20	2	13.19	11	13.47
Quercus michauxii Nutt.	10	1	0	0	0	0	0	0	10	1	6.60	2	6.60
Ilex opaca Ait.	7	12	10	1	0.28	10	2	3.34	0	0	0	15	3.62
Liquidambar styraciflua L.	40	4	20	4	0.56	10	1	1.67	0	0	0	9	2.23
Carpinus caroliniana Walt.	10	54	100	15	1.77	0	0	0	0	0	0	69	1.77
Quercus nuttallii Palm.	0	0	10	2	0.37	0	0	0	0	0	0	2	0.37
Nyssa sylvatica Marsh.	20	5	10	2	0.37	0	0	0	0	0	0	7	0.37
Forestiera acuminata (Michx.) Poir.	50	8	0	0	0	0	0	0	0	0	0	8	0
Ulmus americana L.	20	5	0	0	0	0	0	0	0	0	0	5	0
Ilex decidua Walt.	30	4	0	0	0	0	0	0	0	0	0	4	0
Carya tomentosa Nutt.	10	1	0	0	0	0	0	0	0	0	0	1	0
Fraxinus pennsylvanica Marsh.	10	1	0	0	0	0	0	0	0	0	0	1	0
Crataegus viridis L.	10	1	0	0	0	0	0	0	0	0	0	1	0
Morus rubra L.	10	1	0	0	0	0	0	0	0	0	0	1	0
Vaccinium elliottii Chapm.	10	1	0	0	0	0	0	0	0	0	0	1	0
Smilax bona-nox L.	10	1	0	0	0	0	0	0	0	0	0	1	0
Vitis rotundifolia Michx.	10	1	0	0	0	0	0	0	0	0	0	1	0

* dbh = diameter breast high (1.47 m), F = percent frequency, D = density, and BA = basal area. Species arrangement is from highest to lowest total basal area.

** Where possible, nomenclature follows that of Correll and Correll (1975); otherwise, Radford, Ahles, and Bell (1968).

Table 3

Composition of the Woody Flora of the Hurricane Creek Study Area*

	Saplings dbh <2.5 cm		Trees: dbh ≥2.5 cm to <15 cm			Trees: dbh ≥15 cm to <38 cm			Trees: dbh ≥38 cm			Total For All Size Classes	
Species**	F	D	F	D	BA, m^2	F	D	BA, m^2	F	D	BA, m^2	D	BA, m^2
Liquidambar styraciflua L.	20	4	30	4	0.93	100	15	17.09	30	5	14.40	28	32.42
Ilex opaca Ait.	30	6	20	2	0.37	30	5	6.50	20	2	5.76	15	12.63
Carya cordiformis (Wang.) K. Koch	10	1	10	2	0.37	20	2	3.34	10	1	2.88	6	6.59
Carpinus caroliniana Walt.	70	14	100	23	3.81	30	2	1.49	0	0	0	39	5.30
Carya tomentosa Nutt.	10	4	0	0	0	10	1	0.24	20	2	4.55	7	4.79
Carya ovata (Mill.) K. Koch	10	1	20	2	0.37	0	0	0	10	1	2.88	4	3.25
Ulmus americana L.	30	6	10	3	0.28	0	0	0	10	1	2.88	10	3.16
Quercus laurifolia Michx.	20	2	20	2	0.37	0	0	0	10	1	2.88	5	3.25
Nyssa sylvatica Marsh.	20	6	10	1	0.09	10	2	2.42	0	0	0	9	2.51
Morus rubra L.	10	2	10	1	0.28	10	1	1.67	0	0	0	4	1.95
Quercus michauxii Nutt.	0	0	10	2	0.84	0	0	0	0	0	0	2	0.84
Ulmus alata Michx.	10	1	20	2	0.37	0	0	0	0	0	0	3	0.37
Acer rubrum L.	10	2	10	1	0.28	0	0	0	0	0	0	3	0.28
Betula nigra L.	0	0	10	1	0.28	0	0	0	0	0	0	1	0.28
Sassafras albidum Nutt.	10	3	10	1	0.09	0	0	0	0	0	0	4	0.09
Forestiera acuminata (Michx.) Poir.	50	8	0	0	0	0	0	0	0	0	0	8	0
Quercus phellos L.	60	14	0	0	0	0	0	0	0	0	0	14	0
Fraxinus pennsylvanica Marsh.	10	2	0	0	0	0	0	0	0	0	0	2	0
Symplocos tinctoria (L.) L'Her.	20	2	0	0	0	0	0	0	0	0	0	2	0
Quercus falcata Michx. var. *pagodaefolia* Ell.	10	1	0	0	0	0	0	0	0	0	0	1	0
Arundinaria gigantea (Walt.) Muhl.	10	1	0	0	0	0	0	0	0	0	0	1	0
Vitis rotundifolia Michx.	10	1	0	0	0	0	0	0	0	0	0	1	0
Smilax bona-nox L.	10	1	0	0	0	0	0	0	0	0	0	1	0

* dbh = diameter breast high (1.47 m), F = percent frequency, D = density, and BA = basal area. Species arrangement is from highest to lowest total basal area.

** Where possible, nomenclature follows that of Correll and Correll (1975); otherwise, Radford, Ahles, and Bell (1968).

Table 4

Composition of the Woody Flora of the Moro Creek Study Area*

Species**	Saplings dbh <2.5 cm F	D	Trees: dbh ≥2.5 cm to <15 cm F	D	BA, m^2	dbh ≥15 cm to <38 cm F	D	BA, m^2	dbh ≥38 cm F	D	BA, m^2	Total For All Size Classes D	BA, m^2
Quercus nigra L.	10	1	20	3	0.65	30	5	5.57	10	1	2.88	10	9.10
Nyssa sylvatica Marsh.	20	5	0	0	0	0	0	0	10	1	6.60	6	6.60
Liquidambar styraciflua L.	90	21	40	6	0.93	10	2	2.42	10	1	2.88	30	6.23
Carpinus caroliniana Walt.	100	45	90	11	1.77	0	0	0	10	1	2.88	57	4.65
Quercus lyrata Walt.	0	0	0	0	0	10	1	1.67	10	1	2.88	2	4.55
Pinus taeda L.	10	1	10	1	0.09	10	1	1.67	0	0	0	3	1.76
Ulmus alata Michx.	50	11	20	2	0.28	10	1	0.74	0	0	0	14	1.02
Quercus laurifolia Michx.	10	3	10	3	0.28	0	0	0	0	0	0	6	0.28
Forestiera acuminata (Michx.) Poir.	0	0	10	2	0.19	0	0	0	0	0	0	2	0.19
Quercus nuttallii Palm.	20	4	10	2	0.19	0	0	0	0	0	0	6	0.19
Carya ovata (Mill.) K. Koch	10	2	10	1	0.09	0	0	0	0	0	0	3	0.09
Quercus phellos L.	60	13	0	0	0	0	0	0	0	0	0	13	0
Vaccinium arboreum Marsh.	30	11	0	0	0	0	0	0	0	0	0	11	0
Crataegus sp. L.	30	8	0	0	0	0	0	0	0	0	0	8	0
Planera aquatica (Walt.) J.F. Gmel.	10	2	0	0	0	0	0	0	0	0	0	2	0
Betula nigra L.	10	2	0	0	0	0	0	0	0	0	0	2	0
Quercus falcata Michx. var. *pagodaefolia* Ell.	20	2	0	0	0	0	0	0	0	0	0	2	0
Styrax americana Lam.	10	2	0	0	0	0	0	0	0	0	0	2	0
Ilex opaca Ait.	40	8	0	0	0	0	0	0	0	0	0	8	0
Vitis rotundifolia Michx.	10	2	0	0	0	0	0	0	0	0	0	2	0
Smilax bona-nox L.	10	1	0	0	0	0	0	0	0	0	0	1	0

* dbh = diameter breast high (1.47 m), F = percent frequency, D = density, and BA = basal area. Species arrangement is from highest to lowest total basal area.

** Where possible, nomenclature follows that of Correll and Correll (1975); otherwise, Radford, Ahles, and Bell (1968).

Table 5

Composition of the Woody Flora of the Smackover Creek Study Area*

	Saplings dbh <2.5 cm		Trees									Total For All Size Classes	
			dbh ≥2.5 cm to <15 cm			dbh ≥15 cm to <38 cm			dbh ≥38 cm				
Species**	F	D	F	D	BA, m^2	F	D	BA, m^2	F	D	BA, m^2	D	BA, m^2
Liquidambar styraciflua L.	0	0	30	8	1.47	30	4	3.90	0	0	0	12	5.37
Quercus nigra L.	30	8	20	4	0.93	10	2	2.42	0	0	0	14	3.35
Pinus taeda L.	0	0	0	0	0	0	0	0	10	1	2.88	1	2.88
Quercus phellos L.	20	5	20	4	0.93	10	1	0.74	0	0	0	10	1.67
Carpinus caroliniana Walt.	100	22	60	8	0.93	10	1	0.74	0	0	0	31	1.67
Quercus durandii Buckl.	0	0	0	0	0	10	1	1.67	0	0	0	1	1.67
Nyssa sylvatica Marsh.	10	2	10	1	0.09	10	1	0.74	0	0	0	4	0.83
Quercus laurifolia Michx.	0	0	0	0	0	10	1	0.74	0	0	0	1	0.74
Carya tomentosa Nutt.	10	1	10	1	0.28	0	0	0	0	0	0	2	0.28
Morus rubra L.	0	0	10	1	0.09	0	0	0	0	0	0	1	0.09
Ulmus alata Michx.	0	0	10	1	0.09	0	0	0	0	0	0	1	0.09
Ilex decidua Walt.	10	2	10	1	0.09	0	0	0	0	0	0	3	0.09
Carya aquatica (Michx.) Nutt.	0	0	10	1	0.09	0	0	0	0	0	0	1	0.09
Ulmus americana L.	60	8	0	0	0	0	0	0	0	0	0	8	0
Symplocos tinctoria (L.) L'Her.	10	1	0	0	0	0	0	0	0	0	0	1	0
Smilax bona-nox L.	10	1	0	0	0	0	0	0	0	0	0	1	0
Anisostichus capreolata (L.) Bur.	10	1	0	0	0	0	0	0	0	0	0	1	0

* dbh = diameter breast high (1.47 m), F = percent frequency, D = density, and BA = basal area. Species arrangement is from highest to lowest total basal area.

** Where possible, nomenclature follows that of Correll and Correll (1975); otherwise, Radford, Ahles, and Bell (1968).

Table 6

Composition of the Woody Flora of the Saline River Study Area*

	Saplings dbh <2.5 cm		Trees: dbh ≥2.5 cm to <15 cm			Trees: dbh ≥15 cm to <38 cm			Trees: dbh ≥38 cm			Total For All Size Classes	
Species**	F	D	F	D	BA,m^2	F	D	BA,m^2	F	D	BA,m^2	D	BA,m^2
Liquidambar styraciflua L.	100	14	60	9	1.95	40	7	4.74	10	1	0.74	31	7.43
Quercus falcata Michx. var. *pagodaefolia* Ell.	30	6	10	1	0.09	20	3	5.76	0	0	0	10	5.85
Celtis laevigata Willd.	20	4	10	1	0.09	10	2	3.34	0	0	0	7	3.43
Carpinus caroliniana Walt.	100	25	50	7	1.49	0	0	0	0	0	0	32	1.49
Carya ovata (Mill.) K. Koch	10	1	10	2	0.37	0	0	0	0	0	0	3	0.37
Nyssa sylvatica Marsh.	10	2	10	2	0.37	0	0	0	0	0	0	4	0.37
Ulmus americana L.	20	2	20	3	0.28	0	0	0	0	0	0	5	0.28
Quercus lyrata Walt.	0	0	10	1	0.28	0	0	0	0	0	0	1	0.28
Quercus nigra L.	0	0	10	2	0.19	0	0	0	0	0	0	2	0.19
Morus rubra L.	0	0	10	2	0.19	0	0	0	0	0	0	2	0.19
Quercus phellos L.	0	0	10	1	0.09	0	0	0	0	0	0	1	0.09
Ulmus alata Michx.	10	1	10	1	0.09	0	0	0	0	0	0	2	0.09
Forestiera acuminata (Michx.) Poir.	80	31	0	0	0	0	0	0	0	0	0	31	0
Diospyros virginiana L.	20	6	0	0	0	0	0	0	0	0	0	6	0
Ilex opaca Ait.	10	1	0	0	0	0	0	0	0	0	0	1	0
Pinus taeda L.	10	1	0	0	0	0	0	0	0	0	0	1	0
Crataegus viridis L.	10	1	0	0	0	0	0	0	0	0	0	1	0
Acer rubrum L.	10	1	0	0	0	0	0	0	0	0	0	1	0
Vitis rotundifolia Michx.	10	1	0	0	0	0	0	0	0	0	0	1	0
Smilax bona-nox L.	10	1	0	0	0	0	0	0	0	0	0	1	0

* dbh = diameter breast high (1.47 m), F = percent frequency, D = density, and BA = basal area. Species arrangement is from highest to lowest total basal area.

** Where possible, nomenclature follows that of Correll and Correll (1975); otherwise, Radford, Ahles, and Bell (1968).

Table 7

Composition of the Understory Vegetation <1.3 cm Tall Within the Five Sites Studied*

Species**	Cornie Bayou C	Cornie Bayou F	Hurricane Creek C	Hurricane Creek F	Moro Creek C	Moro Creek F	Saline River C	Saline River F	Smackover Creek C	Smackover Creek F
Moss spp.	18	60	<1	10	18	70	5	30	<1	10
Anisostichus capreolata (L.) Bur.	0	0	<1	10	0	0	5	20	0	0
Aster simplex Willd.	0	0	0	0	0	0	<1	10	0	0
Bare Ground	63	100	38	100	38	100	63	100	88	100
Berchemia scandens (Hill) K. Koch	5	30	18	0	5	50	5	30	5	10
Campsis radicans (L.) Seem.	5	10	0	0	0	0	5	30	0	0
Chasmanthium sessiliflora (Poir.) Yates	5	30	18	60	18	60	<1	10	<1	10
Commelina virginica L.	0	0	0	0	0	0	0	0	<1	10
Elephantopus carolinianus Willd.	<1	10	<1	10	5	20	5	20	<1	10
Hypericum hypericoides L.	<1	10	5	20	<1	10	<1	10	5	20
Trachelospermum difforme (Walt.) Gray	0	0	0	0	0	0	0	0	<1	10
Panicum spp. L.	5	30	5	0	<1	0	<1	10	<1	10
Rhus toxicodendron L.	5	50	5	70	5	50	5	70	5	10
Smilax bona-nox L.	0	0	<1	10	5	10	5	20	0	0
Smilax glauca Walt.	0	0	<1	10	0	0	0	0	0	0
Solidago angustifolia Ell.	0	0	<1	10	<1	10	0	0	0	0

* C = % Cover/0.04 ha; F = % Frequency/0.04 ha. Percent cover data consist of mean estimates based on the following scale for guided estimation: <1 ≠ 0; ≥1 < 10; ≥10 < 25; ≥25 < 50; ≥50 < 75; ≥75 < 100; and 100.

** Where possible, nomenclature follows that of Correll and Correll (1975); otherwise, Radford, Ahles, and Bell (1968).

duration patterns that occurred during the growing season between 1962 and 1974 (Table 8). Specifically, the results indicated that seedlings and saplings of *Carpinus caroliniana* can develop on habitats that are repeatedly flooded for short durations of time. *Liquidambar styraciflua* L. (sweet gum) seedlings and saplings develop well on floodplain habitats flooded during the early spring portion of the growing season followed by one or more short-duration floods during the midspring. *Quercus falcata* Michx. var. *pagodaefolia* Ell. (cherrybark oak) seedlings and saplings develop well only on those floodplain habitats where one or more short-duration floods occur during early spring. Juvenile forms of *Nyssa sylvatica* Marsh. (blackgum) and *Quercus nigra* L. (water oak) appear to do poorly in habitats where one or more short-duration floods occurred after midspring.

14. No significant correlations between flood timing and duration and the basal area were found for *Carya ovata* (Mill.) K. Koch. This lack of significant correlation is similar to the findings of Boisen and Newlin (1910) and Barton (1936). These authors suggest that competition seems to be a key habitat factor in determining success for *Carya ovata*. This lack of correlation may therefore point to the fact that on floodplain habitats where *Carya ovata* occurs, certain flooding events may allow this species to have an advantage by the elimination of certain types of interspecies competition.

Discussion

15. The specific habitat-species relationships found in this study agree with those found in literature (Fowells 1965; Baker and Broadfoot 1977; Whitlow and Harris 1979). Evidence has been provided to indicate how floodplain forest community structure can be influenced by the timing and duration of floods occurring during the growing season. These results provide additional information on the variation in plant community types that occurs along floodplains of the southeastern United States (Wells 1928, 1932, and 1942; Braun 1967; Marks and Harcombe 1975), as well as other floodplains, since considerable range of variation in

Table 8

Correlation Coefficients Showing Response to Varied Flood Timing and Duration During the Growing Season

Species Studied	(A)*	(B)	(C)	(D)
Carpinus caroliniana Walt.	-0.16	-0.08	0.84**	-0.10
Carya ovata (Mill.) K. Koch	0.23	-0.08	0.57	-0.10
Liquidambar styraciflua L.	-0.56	0.96†	0.08	0.02
Nyssa sylvatica Marsh.	0.66	0.44	-0.18	-0.96†
Quercus falcata Michx. var. *pagodaefolia* Ell.	0.97†	-0.19	-0.41	-0.87**
Quercus nigra L.	0.29	-0.08	-0.82**	-0.10

* See Table 1 for interpretation of letter designations.
** Significant at $p \leq 0.05$ level.
† Significant at $p \leq 0.01$ level.

the timing and duration of flooding is common throughout these lowland areas.

16. Over 60 woody species occur on various floodplains or bottomlands of the Southeastern United States. They grow and develop in varying types of flooded and nonflooded habitats. Moisture requirements for seed germination vary; but as with most plant species, anaerobic soil conditions brought about by flooding and/or soil saturation are typically inhibitory. Developing seedlings, saplings, and mature adults all appear to vary in their degree of tolerance to flooding. Therefore, variation in time of flooding and its duration can sustain or significantly influence the development of certain plant community types. Repeated flooding and the resultant anaerobism, such as those described in the study, are selective for those species which have morphological and/or physiological mechanisms that allow for survival under periodic anaerobic conditions.

17. Intolerance to soil anaerobism is also an important factor in the development of various floodplain community types. It serves to exclude those species that might otherwise grow there if the soils were not anaerobic during part of the growing season. This becomes evident in those areas where flooding and/or soil saturation are no longer a factor, since these species then commonly invade. Predominant intolerant woody species within the region of study are *Pinus echinata* Mill. (shortleaf pine) and *Quercus marilandica* Muenchh. (blackjack oak).

18. In communities that border periodically flooded habitats, tolerance to inundation and/or soil saturation ceases to be a dominant environmental factor controlling community structure. Factors such as shade tolerance and soil type appear more significant in the fecundity of associated species (Voigt and Mohlenbrock 1964).

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Huffman, Robert Terry
The relation of flood timing and duration to variation in selected bottomland hardwood communities of southern Arkansas / by Robert Terry Huffman. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1980.
22 p. : ill. ; 27 cm. (Miscellaneous paper - U. S. Army Engineer Waterways Experiment Station ; EL-80-4)
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References: p. 21-22.

1. Community. 2. Flood plains. 3. Flooding. 4. Forests. 5. Hardwoods. I. United States. Army. Corps of Engineers. II. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper ; EL-80-4.
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